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Masuda et al.

[11] **4,400,139**

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[54] **OIL PUMP**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **417/304;** 417/308; 417/310

[58] **Field of Search** 417/300, 302, 304, 308, 417/310

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,755,741	7/1956	Erskine	417/304 X
3,366,065	1/1968	Pace et al.	417/302
3,415,194	12/1968	Connelly	417/304

FOREIGN PATENT DOCUMENTS

918122	2/1963	United Kingdom	417/310

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[57] **ABSTRACT**

A pair of pump bodies are disposed on the opposite sides of a rotor having vanes and a cam ring disposed in surrounding relationship with the rotor. These pump bodies serve the function of a sideplate and a pressure plate. The rotary shaft of the rotor is rotatably journaled in one of the pump bodies. A flow control valve is disposed in alignment with the axis of the other pump body, and a relief valve is disposed in surrounding relationship with the flow control valve. In this manner, the construction of various parts is simplified and the number of parts is reduced while simultaneously facilitating the machining operation. The overall length and the outer diameter as well as the weight of the pump can be reduced, advantageously reducing the manufacturing cost of the pump. The construction is further simplified by providing a cup-shaped casing around the pump body which functions as the pressure plate so that a space defined laterally of the pump body forms a pressure chamber on the discharge side of the pump.

4 Claims, 4 Drawing Figures

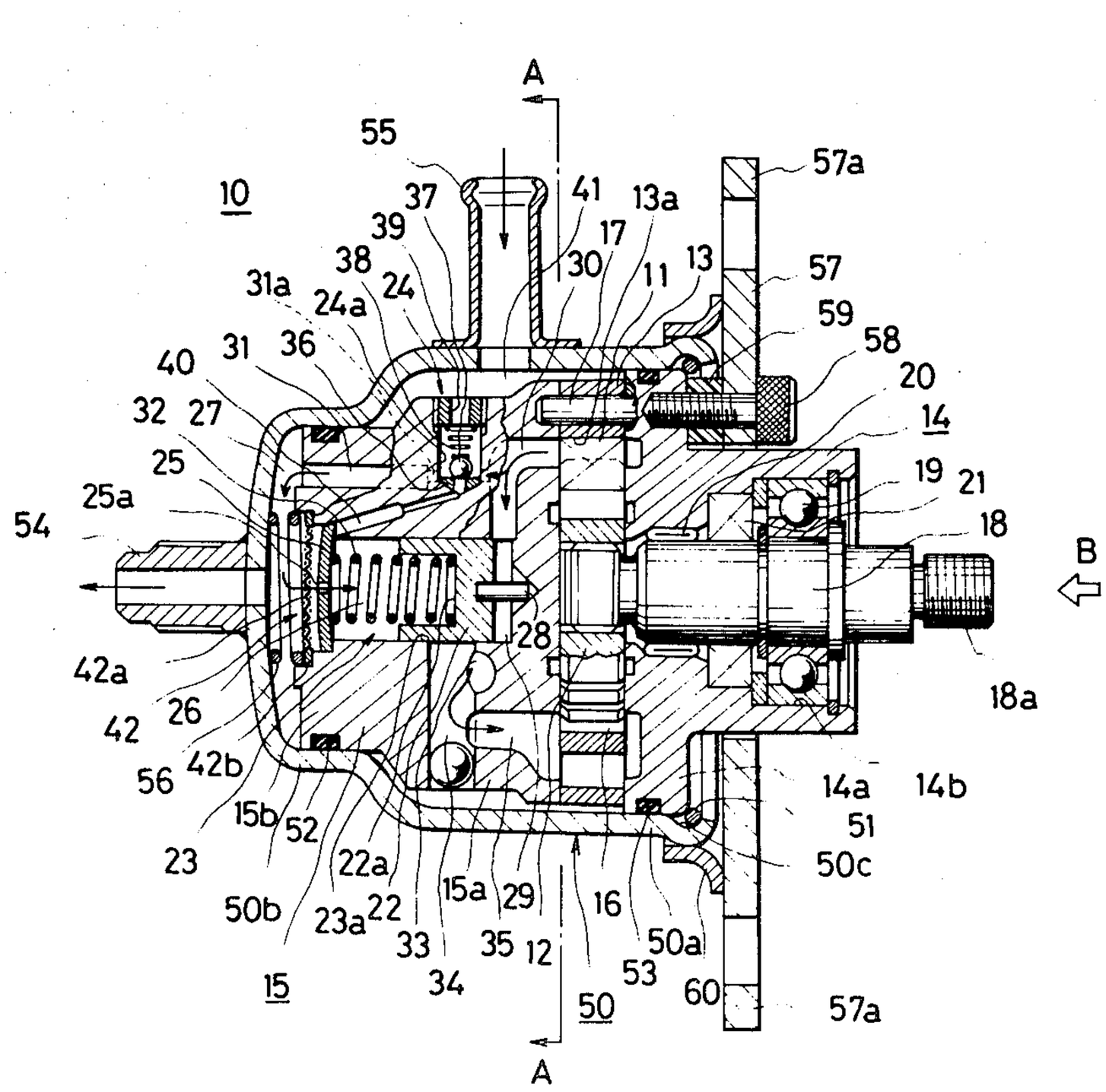

FIG. 1

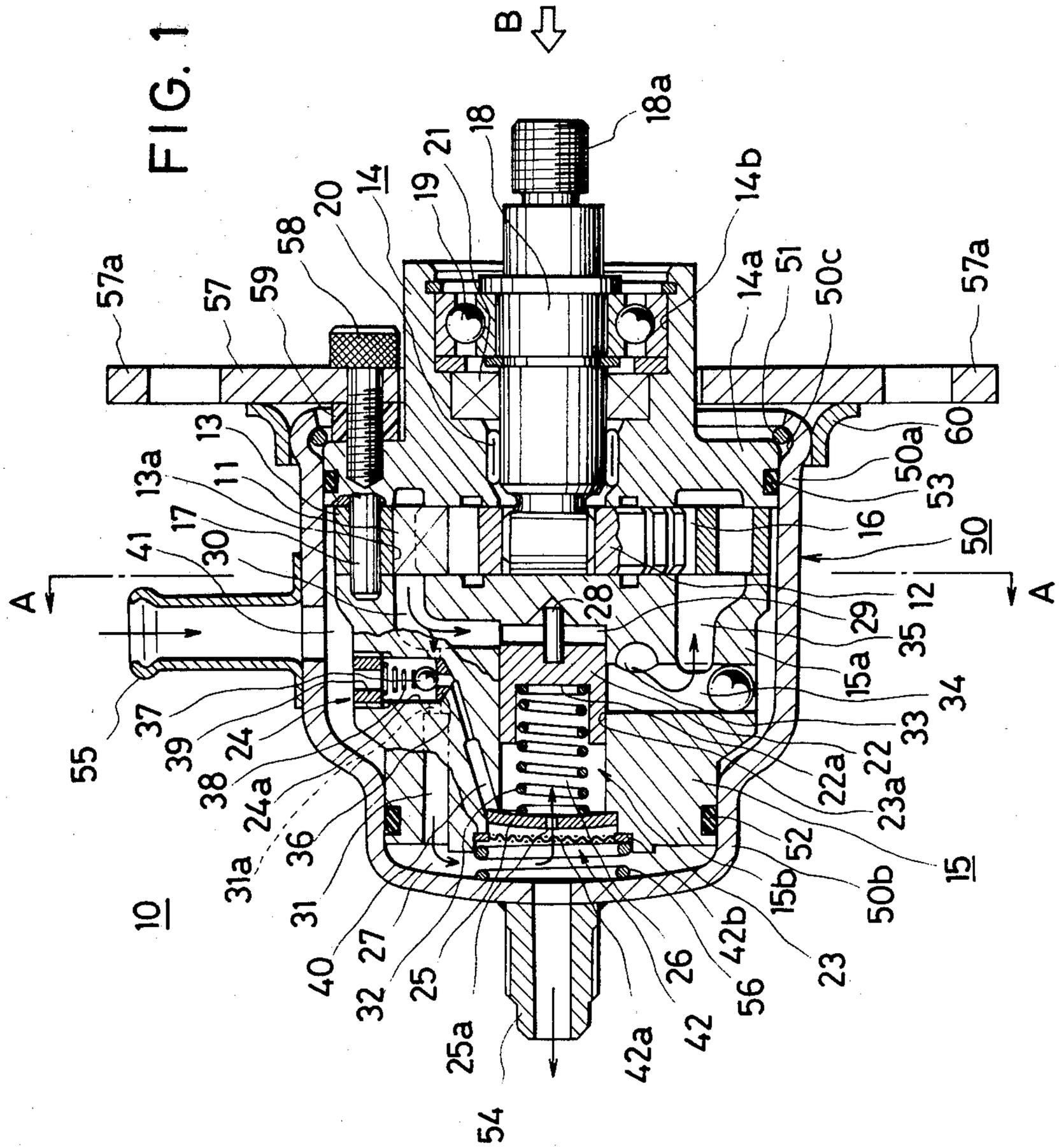
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FIG. 3

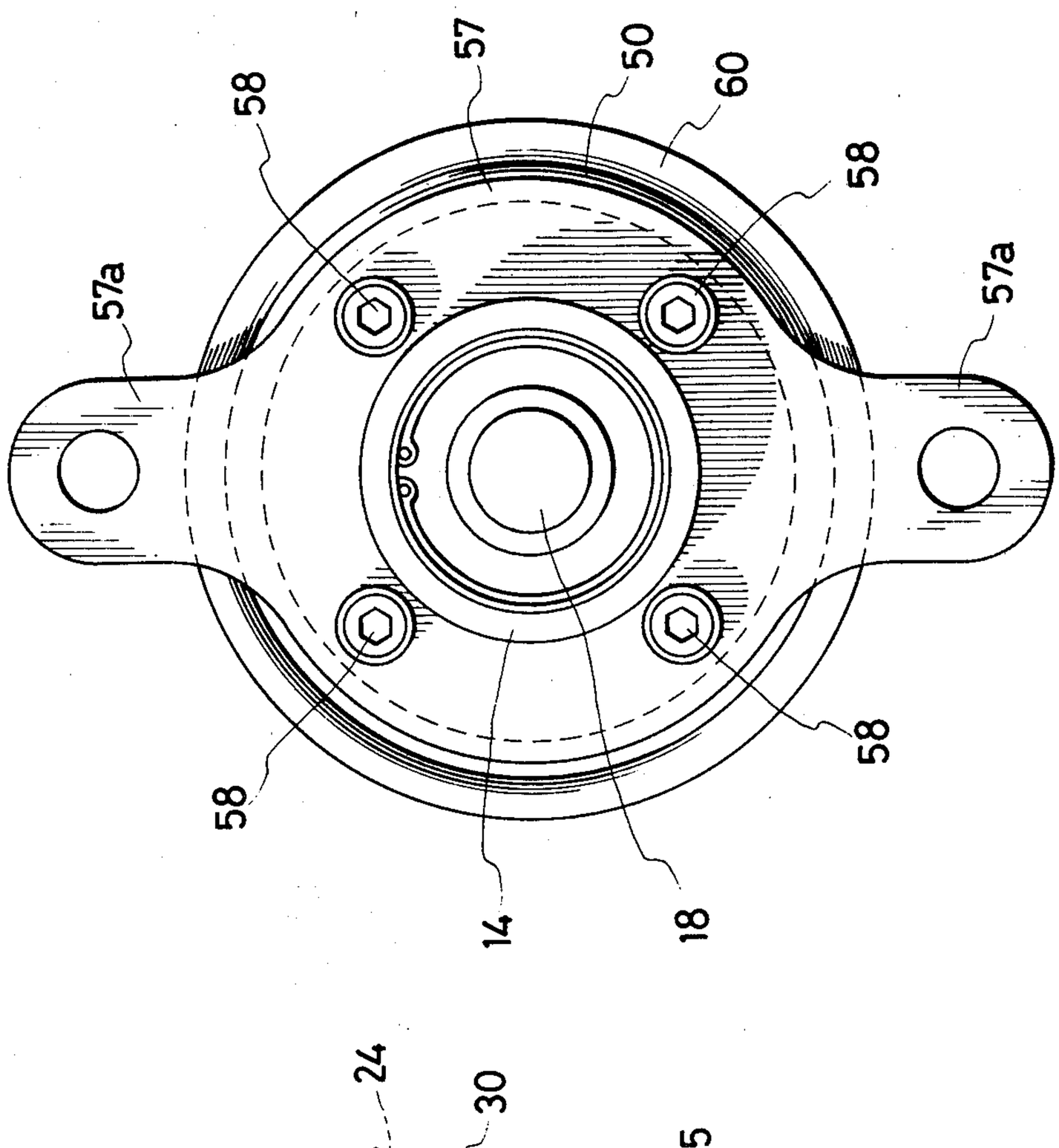


FIG. 2

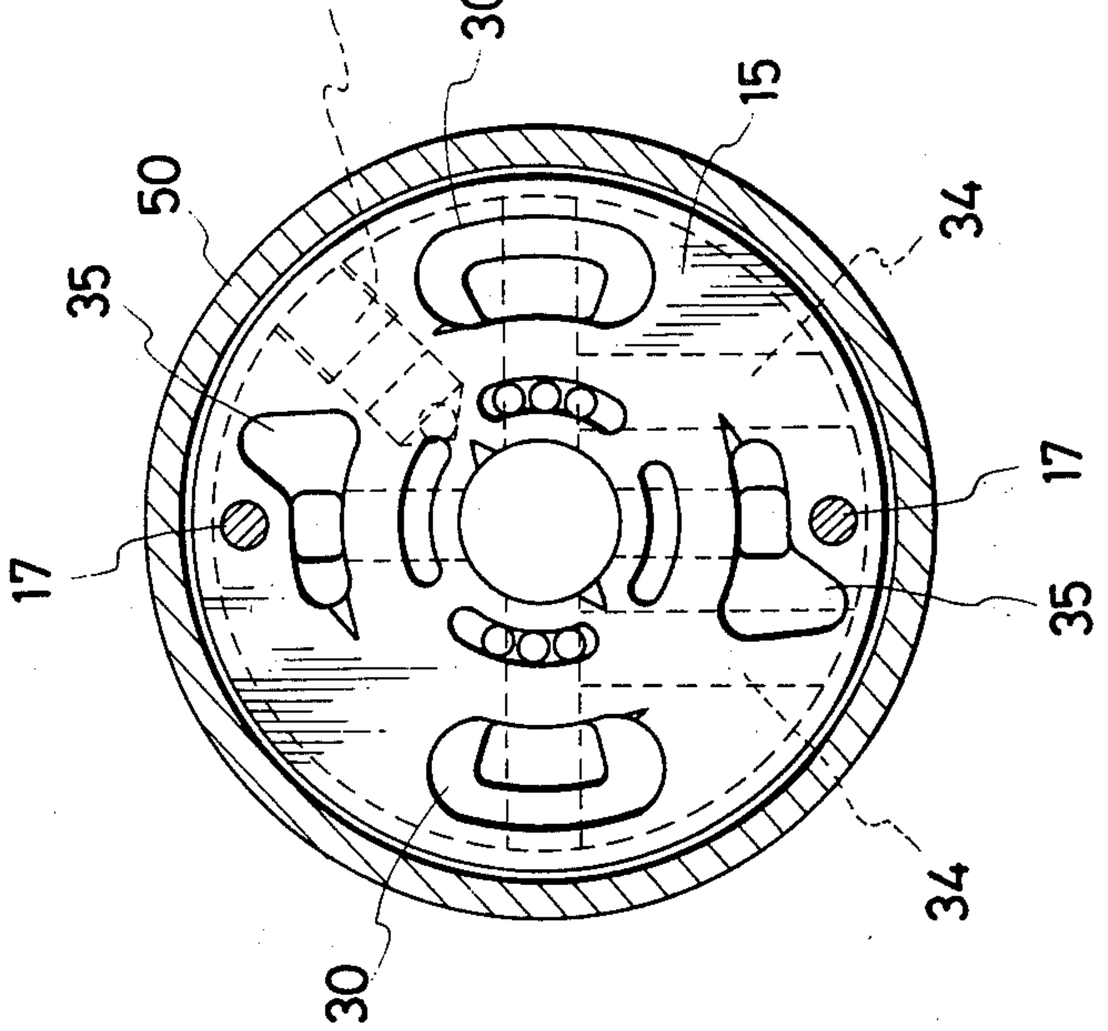
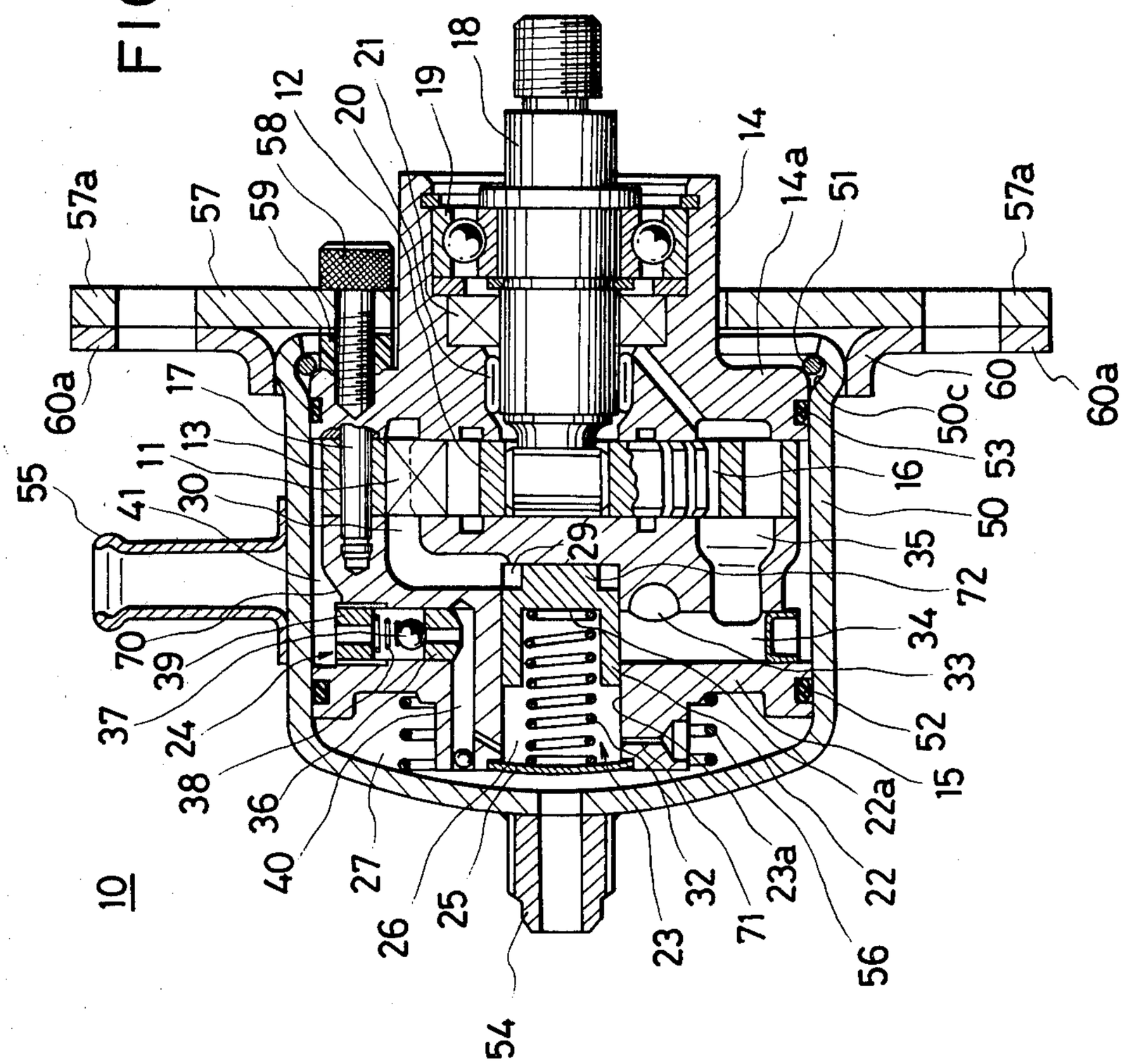


FIG. 4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OIL PUMP

BACKGROUND OF THE INVENTION

The invention relates to an oil pump of the vane type which can, for example, be used in a power steering apparatus utilized to facilitate handling of a steering wheel of an automobile.

An oil pump of this kind generally comprises a rotor having a plurality of radially extending slits in which a plurality of vanes are slidably assembled, a cam ring having a cam surface of substantially elliptical form and disposed in surrounding relationship with the rotor, and a sideplate and a pressure plate disposed on the opposite sides of the combination of the rotor and the cam ring to define a pump chamber together with the cam ring. As the rotor rotates, the vanes disposed in the slits move in a reciprocating manner, with their outer ends disposed in sliding contact with the cam surface to provide a pumping function. An oil pump of the vane type permits its operation at a reduced noise level while utilizing a relatively simple construction and presents a high operational reliability and freedom from failures. Because of these advantages, it finds an extensive application in a variety of fields.

In the conventional construction of such an oil pump, the components of the pump including the rotor, the cam ring, the sideplate and the pressure plate are disposed in a space defined within a pump body, through which a rotary shaft of the rotor extends and is rotatably journaled. This increases the overall length and the outer diameter as well as the weight of the pump. In addition, it requires an increased number of parts, many of which must be machined in a troublesome operation. All of these factors contribute to increasing the manufacturing cost of the pump.

It should be noted that the problem is even more aggravated if a flow control valve controlling the flow rate of an operating or hydraulic oil discharged from the pump chamber and a relief valve which maintains the oil pressure below a given value must be integrally disposed within the pump body, as required in an oil pump which is used in a power steering apparatus, for example. Specifically, if the flow control valve and the relief valve are integrally mounted on the pump in surrounding relationship or laterally of the pump components, the outer diameter or the overall length of the pump body will further increase. Such result is particularly notable in many oil pump arrangements having a relief valve which is assembled into a flow control valve, thus presenting an increased overall length of the valve.

On the other hand, an oil pump of the type which is utilized in a power steering apparatus is subject to a number of limitations in view of the limited space available within an engine compartment and the desirability of reducing its influence upon the entire weight and the cost of an automobile. Therefore, it is apparent that there has been a need in the art to eliminate the described difficulties by providing an oil pump which is small in size and low in weight and inexpensive to manufacture.

SUMMARY OF THE INVENTION

Therefore, it is an object of the invention to provide an oil pump which is inexpensive to manufacture and has a reduced overall length and outer diameter.

This object is achieved by providing a pair of pump bodies on the opposite sides of a rotor containing vanes and a cam ring in which the rotor is disposed. The individual pump bodies serve as a sideplate and a pressure plate. The rotary shaft of the rotor is rotatably journaled in one of the pump bodies while a flow control valve is disposed in the other pump body together with a relief valve which is disposed in surrounding relationship with the flow control valve for maintaining the hydraulic pressure below a given value.

It is another object of the invention to provide an oil pump which achieves the described results and facilitates the machining, by providing a cup-shaped casing in surrounding relationship with the pump bodies so that a space defined laterally of the pump body may be utilized as a discharge pressure chamber of the pump.

Other objects, features and advantages of the invention will become apparent from the following description given in connection with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal section of an oil pump according to one embodiment of the invention;

FIG. **2** is a cross section taken along the line A—A shown in FIG. **1**;

FIG. **3** is a side elevation as viewed in a direction indicated by an arrow B shown in FIG. **1**; and

FIG. **4** is a longitudinal section of another embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. **1** to **3**, there is shown an oil pump of vane type according to one embodiment of the invention. It is to be understood that the invention will be described hereinbelow as applied to a power steering apparatus. An oil pump generally designated by numeral **10** includes a rotor **12** having a plurality of vanes **11**, which are surrounded by a cam ring **13** having a substantially elliptical cam surface **13***a*. A first and a second pump body **14**, **15** are disposed on opposite sides of the rotor **12** and the cam ring **13** in abutting relationship with the latter. The combination of the first and the second pump bodies **14**, **15** and the cam ring **13** defines a pump chamber **16** into which an operating oil from an oil tank is withdrawn and from which it is discharged. In this manner, the first and the second pump bodies **14**, **15** serve the same purpose as a sideplate and a pressure plate which have been used in the prior art. A pair of pins **17** extending through the cam ring **13** are a close fit in both the first and the second pump bodies **14**, **15** to prevent relative rotation between them.

The first pump body **14** includes a flange **14***a* of a diameter which is slightly greater than that of the cam ring and which abuts against one lateral side of the rotor **12** and the cam ring **13**. The pump body **14** is formed with an axial bore **14***b* through which the rotary shaft **18** of the rotor **12** extends and is rotatably journaled in a ball bearing **19** and needle bearing **20**. The inner end of the rotary shaft **18** is splined to the rotor **12** while its threaded outer end **18***a* has a pulley, not shown, mounted thereon which is coupled to an engine of an automobile through a V-belt. An oil seal is shown at **21**.

The second pump body **15** is disposed in abutment against the other lateral side of the rotor and the cam ring **13**, and has a larger portion **15***a* of a diameter which is substantially equal to that of the cam ring **13** and a smaller portion **15***b* having a reduced diameter.

Centrally disposed within the second pump body **15** is a flow control valve **23** for controlling the flow rate of a hydraulic oil from the pump chamber **16**, the valve **23** including a spool **22** which is movable along the axis thereof. Radially outwardly of the flow control valve **23** is a relief valve **24** which maintains the hydraulic pressure of the oil from the pump chamber **16** below a given value.

More specifically, the flow control valve **23** is formed with a valve opening **23***a* aligned with the axis of the second pump body **15** and which opens into the side of the smaller portion **15***b*. At one end, the valve opening **23***a* is covered by a plug plate **25** having a damper orifice **25***a* centrally formed therein. Introduced into a low pressure chamber **26** defined between the plug plate **25** and the spool **22** is an operating oil from a pressure chamber **27** on the discharge side of the pump, which is defined laterally of the smaller portion **15***b* between the latter and a cup-shaped casing to be described later, through the damper orifice **25***a*. A pin **28** is fixedly mounted on the end plate of the spool **22** located nearest the rotor **12**, and engages the inner end of the valve opening **23***a*, thus defining a high pressure chamber **29**, into which part of the operating oil from the pump chamber **16** is introduced through a passage **30** which is formed in the second pump body **15**. Intermediate its length, the passage **30** branches into another passage **31** which extends axially of the second pump body **15** and which opens into the pressure chamber **27**. Intermediate its length, the passage **31** is formed with an orifice **31***a*, which produces a pressure differential between the oil pressure in the passage **30** and the oil pressure in the pressure chamber **27**. A return spring **32** urges the spool **22** toward the high pressure chamber **29**. To provide for an increased compressed length of the return spring **32** while reducing the overall length of the valve itself, the end of the spool **22** is formed with a recess **22***a*. The second pump body **15** is also formed with passages **33**, **34**, **35** which are utilized to introduce the operating oil from the oil tank into the pump chamber **16**, and part of the passage **34** opens into the valve opening **23***a*. The passage **34** is normally blocked by the spool **22**, but communicates with the passage **30** through the high pressure chamber **29** to define a circulation path for returning the operating oil from the pump chamber **16** to the suction side whenever the spool **22** is actuated.

The relief valve **24** is formed with a valve opening **24***a* which opens into the outer periphery of the larger portion **15***a* of the second pump body **15**. A valve seat **36** is a press fit into the bottom of the valve opening **24***a*, and is formed with an aperture which is blocked by a ball **37**, which is in turn urged against the aperture by a spring **38** having its other end abutting against a set screw **39**. By adjusting the degree of threadable engagement of the set screw **39**, the relief valve **24** can be preset to operate at a given pressure. The relief valve **24** normally communicates with the low pressure chamber **26** in the flow control valve **23** through a passage **40**, and also communicates with the pressure chamber **27** on the discharge side through the damper orifice **25***a*. On the other hand, a pressure chamber **41** on the suction side of the pump is defined in the cup-shaped casing in a region of the outer periphery of the larger portion **15***a* into which the valve opening **24***a* of the relief valve **24** opens, thus returning the oil to the suction side whenever the pressure within the discharge pressure chamber **27** exceeds a given value.

It is to be noted that impurities such as iron powder or deteriorations may be contained in the operating oil from the discharge side of the pump which is supplied to the relief valve **24** through the passage **40**, and may become deposited on the valve seat **36** or the ball **37**, thus precluding their normal operation. For this reason, a conventional oil pump of this kind is provided with a filter which is disposed in a passage introducing the operating oil into a relief valve so as to remove foreign matter from the operating oil. However, the arrangement is susceptible to plugging because of the reduced diameter of the passage, requiring a frequent change or washing operation. To eliminate such problem, in the present embodiment, the passage **40** associated with the relief valve **24** opens into the low pressure chamber **26** of the flow control valve **23**, and a filter **42** is disposed at the end of the valve opening **23***a* so as to be located outside the plug plate **25**, based on the recognition that the operating oil is introduced through the damper orifice **25***a* formed in the plug plate **25** which is located in the larger end of the valve opening **23***a*. The filter **42** comprises a mesh screen **42***a* and its surrounding annular ring **42***b*, which is fitted into the end of the valve opening **23***a*. An increased diameter of the valve opening **23***a* as compared with that of the passage **40** reduces the likelihood that the mesh screen **42***a* may be plugged, while positively cleaning the operating oil. As a result, the operational reliability of the relief valve **24** is assured.

The components of the pump including the rotor **12**, the cam ring **13**, and first and second pump bodies **14**, **15** are all contained in a casing **50** which is generally cup-shaped, as will be noted from FIG. **1**. The casing **50** includes a larger portion **50***a* of an inner diameter which is substantially equal to the outer diameter of the flange **14***a* of the first pump body **14**, and a smaller portion **50***b* of an inner diameter which corresponds to the smaller portion **15***b* of the second pump body **15** and forming the bottom of the casing. The casing can be simply formed by a press operation. Around the inner periphery of the opening end, the casing **50** is formed with an annular groove **50***c*.

The second pump body **15**, the rotor **12** and the cam ring **13**, and the first pump body **14** are sequentially received into the casing **50** in a stacked manner, with the second body **15** being located adjacent the bottom of the casing. A snap ring **51** is fitted into the annular groove **50***c* to lock the flange **14***a* of the first pump body **14**. When assembled in this manner, the smaller portion **15***b* of the second pump body **15** fits in the smaller portion **50***b* of the casing **50**, whereby the pressure chamber **27** representing the discharge side of the pump is defined between the bottom of the casing **50** and the smaller portion **15***b* while the pressure chamber **41** representing the suction side of the pump is defined between the larger portion **50***a* of the casing **50**, the cam ring **13**, and the outer periphery of the larger portion **15***a* of the second pump body **15**. O-ring seals **52**, **53** seal the respective pressure chambers **27**, **41**. A discharge pipe **54** and a suction pipe **55** are disposed to communicate with the pressure chambers **27**, **41**, respectively, through the bottom and the outer peripheral portion of the casing **50**. A spring **56** is disposed within the pressure chamber **27** for urging the entire second pump body **15** against the rotor **12**.

Disposed against the opening end of the casing **50** is a bracket member **57**, with the first pump body **14** and the rotary shaft **18** of the rotor **12**, which is journaled

therein, projecting outward therethrough. The bracket member **57** is secured to the first pump body **14** by four bolts **58** which are circumferentially spaced apart. It will be noted that a collar **59** maintains a given spacing between the bracket member **57** and the first pump body **14**, and also prevents an inward withdrawal of the snap ring **51**. The bracket member **57** includes a mounting piece **57***a* extending outward for allowing the oil pump **10** to be fixedly mounted on a given location as in an engine compartment of an automobile. On its side facing the casing, the bracket member **57** is provided with a cylindrical fitting member **60** which externally engages the opening edge of the casing **50** in order to hold it under pressure. The purpose of the fitting member **60** is to prevent the opening edge of the casing **50** from being urged outward as a result of increased pressure within the casing **50** as the pumping action proceeds.

The oil pump **10** thus constructed has a number of features. Specifically, a sideplate and a pressure plate which are disposed on the opposite sides of the rotor **12** and the cam ring **13** in a conventional arrangement of oil pump and standing in the way to reducing the size of the pump are eliminated in accordance with the invention, by the provision of the first pump body **14** which rotatably carries the rotary shaft **18** of the rotor **12** and of the second pump body **15** containing both the flow control valve **23** and the relief valve **24**, which bodies are disposed directly on the opposite sides of the rotor **12** and the cam ring **13** to serve the function of the sideplate and the pressure plate. In this manner, the construction of the various parts is simplified, permitting a reduction in the number of parts required and facilitating the machining thereof. In addition, the overall length and the outer diameter of the pump can be reduced, thus achieving a reduction in the size and the weight of the pump. A further reduction in the size and the weight of the pump is achieved by disposing the flow control valve **23** in a central region within the second pump body **15** which has a reduced outer diameter than the cam ring **13** and separately disposing the relief valve **24** in surrounding relationship with the flow control valve, and by reducing the axial length of the both valves.

In addition, a space formed between the second pump body **15** and the casing **50** which may be simply formed by a press operation is utilized to define the pressure chamber **27** of the discharge side, the internal pressure of which urges the pump body **15** against the rotor **12**. In this manner, the construction is simplified while avoiding a troublesome machining operation. All these factors contribute to a reduction in the size, the weight and the manufacturing cost of the pump.

The oil pump **10** constructed in the manner mentioned above can be assembled together in a simple manner, by disposing the rotor **12**, the cam ring **13**, and the first and the second pump bodies **14**, **15** in a stacked manner into the casing **50** after various parts have been assembled on these members, fixing the assembly by the snap ring **51** and fitting the bracket member **57** having the fitting member **60** around the opening end of the casing **50**.

The oil pump **10** thus assembled performs a safe, stable and smooth pump operation in a manner to be described below. Specifically, as the rotor **12** rotates, the operating oil from the oil tank is drawn into the pump chamber **16** through the suction pipe **55**, the pressure chamber **41** and the passages **33**, **34** and **35**, and is discharged therefrom by the vane **11** to be fed to the pressure chamber **27** of the discharge side through the passages **30** and **31** and thence supplied to a power steering device through the discharge pipe **54**. Part of the operating oil flowing through the passage **30** is introduced into the high pressure chamber **29** of the flow control valve **23** while the hydraulic oil from the pressure chamber **27** on the discharge side is introduced into the low pressure chamber **26**. As the number of revolutions of the engine of the automobile increases to increase the discharge flow from the pump chamber **16** above a given value, the pressure differential across the spool **22** causes it to move toward the low pressure chamber **26**, whereby the operating oil introduced into the high pressure chamber **29** is returned to the passage **34** of the suction side, thus controlling the discharge flow from the pump. When the pressure within the pressure chamber **27** on the discharge side exceeds the given value, the relief valve **24** becomes operative, returning the operating oil of the discharge side to the pressure chamber **41** of the suction side, assuring the operational reliability of the various parts.

It should be understood that the invention is not limited to an oil pump construction as exemplified by the embodiment mentioned above, but that the construction of various parts can be freely changed in a suitable manner. A modification is illustrated in FIG. **4** where an oil pump **10** includes a cylindrical casing **50** with a bottom, with pump components such as a cam ring **13** and a first and a second pump body **14**, **15** of substantially equal diameter assembled therein. A pressure chamber **41** on the suction side is defined by the outer periphery of the cam ring **13** and an annular groove **70** formed in the outer periphery of the second pump body **15**. A communication is established between the low pressure chamber **26** of a flow control valve **23** and a pressure chamber **27** on the discharge side through a passage **71** of a small diameter which extends diametrically through a lateral projection of the second valve body **15**. In this instance, a plug plate **25** is formed by a blind plate. The flow control valve **23** includes a high pressure chamber **29** which is defined by an annular groove **72** formed in the end of the spool **22**. Other parts are also suitably modified in a manner to facilitate their shaping operation. A fitting member **60** which is fitted around the opening end of the casing **50** includes a mounting piece **60***a* which is disposed in overlapping relationship with the mounting piece **57***a* of a bracket member **57**, so that the mounting pieces **60***a*, **57***a* can be connected together as by bolts.

In the two embodiments described above, the relief valve **24** which is disposed in the second pump body **15** has its valve opening **24***a* terminating in the outer periphery of the pump body and its components assembled in a direction perpendicular to the flow control valve **23** which is centrally disposed in the pump body. However, it should be understood that the invention is not limited thereto, and that the relief vale may be disposed in parallel relationship with the flow control valve.

In the above embodiments, the oil pump **10** has been described as applied to a power steering apparatus, but it should be understood that the invention is not limited thereto in its application, but can be used in a variety of hydraulic instruments where a reduced size and weight is required for the oil pump.

While several embodiments of the invention have been shown and described in detail by way of illustra-

tion, it should be understood that they are illustrative only and not limitative of the invention. Thus, a number of changes and modifications therein will readily occur to those skilled in the art without departing from the scope and spirit of the invention. Therefore, it is intended that the appended claims cover all those changes and modifications as fall within the scope of the invention.

What is claimed is:

1. An oil pump comprising a casing having an inlet and an outlet for hydraulic fluid and having a pump inlet chamber adjacent said inlet and a pump outlet chamber adjacent said outlet, a rotor having a plurality of vanes, a cam ring surrounding said rotor, first and second pump bodies disposed on opposite sides of and in abutting relationship with said rotor and said cam ring, said rotor, said cam ring and said first and second pump bodies being disposed within said casing, said cam ring and said first and second pump bodies defining a pump chamber, said pump chamber having a suction side and a discharge side, said rotor being disposed inside said pump chamber for rotation therein to pump hydraulic fluid from said suction side to said discharge side, said rotor including a shaft which extends through and is rotatably supported in one of said pump bodies, a flow control valve for controlling the rate of flow of hydraulic fluid discharged through said outlet of said casing, a relief valve for maintaining the pressure of said hydraulic fluid discharged through the outlet of said casing below a predetermined value, said flow control valve and said relief valve being disposed in the other of said pump bodies, said other pump body having a first passage extending from said discharge side to said suction side of said pump chamber, said first passage having a high pressure chamber between its ends, said flow control valve being disposed in said high pressure chamber for controlling flow of hydraulic fluid through said first passage, said other pump body having a second passage extending from said discharge side of said pump chamber to said pump outlet chamber, said second passage having a first orifice of restricted size between its ends so that the pressure of the hydraulic fluid upstream from said orifice is higher than the pressure of the hydraulic fluid downstream from said orifice, said flow control valve having a low pressure chamber and an opening into said low pressure chamber, a plug plate covering said opening and having a second, damper orifice extending therethrough, said damper orifice communicating with said second passage at a location therein downstream from said first orifice so that said flow conrol valve is movable in response to the differential of the pressure in said high pressure chamber and said low pressure chamber, said other pump body having a third passage extending between and communicating with said low pressure chamber and said pump inlet chamber, said relief valve being disposed in said third passage so that said relief valve is opened when the hydraulic pressure in said low pressure chamber exceeds a selected value whereby to return the hydraulic fluid to said pump inlet chamber.

2. An oil pump according to claim **1**, including a filter located adjacent to and covering said plug plate.

3. An oil pump comprising a cup-shaped casing having an inlet and an outlet for hydraulic fluid and having a pump inlet chamber adjacent said inlet and a pump outlet chamber adjacent said outlet, a cylindrical fitting member closing the open end of said casing, a rotor having a plurality of vanes, a cam ring surrounding said rotor, a pump body disposed on one side of and in abutting relationship with said rotor and said cam ring, said rotor, said cam ring and said first pump body being disposed within said casing so that the pressure in said discharge chamber urges said pump body against said rotor, said cam ring and said pump body defining a pump chamber, said pump chamber having a suction side and a discharge side, said rotor being disposed inside said pump chamber for rotation therein to pump hydraulic fluid from said suction side to said discharge side, a flow control valve for controlling the rate of flow of hydraulic fluid discharged through said outlet of said casing, a relief valve for maintaining the pressure of said hydraulic fluid discharged through the outlet of said casing below a predetermined value, said flow control valve and said relief valve being disposed in said pump body, said pump body having a first passage extending from said discharge side to said suction side of said pump chamber, said first passage having a high pressure chamber between its ends, said flow control valve being disposed in said high pressure chamber for controlling flow of hydraulic fluid through said first passage, said pump body having a second passage extending from said discharge side of said pump chamber to said pump outlet chamber, said second passage having a first orifice of restricted size between its ends so that the pressure of the hydraulic fluid upstream from said orifice is higher than the pressure of the hydraulic fluid downstream from said orifice, said flow control valve having a low pressure chamber and an opening into said low pressure chamber, a plug plate covering said opening and having a second, damper orifice extending therethrough, said damper orifice communicating with said second passage at a location therein downstream from said first orifice so that said flow control valve is movable in response to the differential of the pressures in said high pressure chamber and said low pressure chamber, said pump body having a third passage extending between and communicating with said low pressure chamber and said pump inlet chamber, said relief valve being disposed in said third passage so that said relief valve is opened when the hydraulic pressure in said low pressure chamber exceeds a selected value whereby to return the hydraulic fluid to said pump inlet chamber.

4. An oil pump according to claim **3**, including a filter disposed adjacent to and covering said plug plate.

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